



**UNIVERSITI PUTRA MALAYSIA**

**RHEOLOGICAL BEHAVIOUR AND PROPERTIES OF INJECTION  
MOULDED OIL PALM (*ELAEIS GUNINEENSIS* JACQ.) EMPTY FRUIT  
BUNCH FIBRES/POLYPROPLENE COMPOSITES)**

**KHALINA BINTI ABDAN.**

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**By**

**KHALINA BINTI ABDAN**

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**RHEOLOGICAL BEHAVIOUR AND PROPERTIES OF INJECTION  
MOULDED OIL PALM (*Elaeis Guineensis* Jacq.) EMPTY FRUIT BUNCH  
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**July 2005**

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**Institute: Advanced Technology**

The feasibility of processing composite prepared from oil palm empty fruit bunch (EFB) /polypropylene (PP) using injection moulding was investigated. The physical, chemical, and thermal characteristics of EFB fibre were studied.

The effects of fibre size, fibre content, levels of melt flow rate and various concentration of maleated polypropylene (MAPP) on the mechanical, physical, rheological and thermal properties of EFB/PP composites were studied. The effects of types and concentrations of reactive additives (RA) on the irradiated EFB/PP composites were also investigated especially to the rheological behaviour and dynamic mechanical thermal characteristics.

The EFB/PP composites were prepared from thermomechanically pulped EFB fibre and PP resin. The internal mixer was used to mix and the injection moulding machine was employed to form the specimen accordance to the

ASTM standards. Electron beam was used to irradiate the EFB/PP composite in order to investigate the effect on dynamic mechanical thermal properties and rheological behaviour. The rheological behaviour was studied using the rheostress viscometer and the results were compared to the melt flow index. Dynamic mechanical thermal properties were measured using a Triton model dynamic mechanical analyser.

The EFB fibre size and fibre content significantly affected the mechanical and physical properties of EFB/PP composites. However the effect of type and concentration of MAPP only affected the tensile and shrinkage properties of the moulded composites.

The rheology of PP showed pseudoplastic behaviour and the viscosity was constant at low shear rate. The changes in fibre size marked different viscosity condition with fine fibre showed viscosity curve away from the matrix curve particularly at very low shear rate. However the 0.1-0.2 mm fibre size revealed the viscosity trend close to the matrix. When MAPP additives were added in the EFB/PP composites the viscosity curve was changed depending on type and concentration level. 2 % of both types of MAPP produced slightly increase in viscosity but 6% of MAPP dropped down the viscosity. The irradiated EFB/PP significantly decrease the viscosity however the composites treated by trimethylol propane triacrylate (TMPTA) showed increase in viscosity but decrease when hexanediol diacrylate or 1,6-hexadiol diacrylate (HDDA) was used.

The dynamic mechanical thermal properties of EFB/PP composites showed that the storage modulus ( $E'$ ) decreases with increase in temperature. The  $E'$  also increases with increase in the fibre loading in the composite. However the  $E'$  was not affected by the fibre size. The EFB/PP composite showed the glass transition temperature ( $T_g$ ) of the composite was shifted to lower temperatures than the  $T_g$  of the pure PP.

The MAPP treatment resulted in a remarkable increase in  $E'$  and loss modulus ( $E''$ ). However the damping property ( $\tan \delta$ ) is less affected. Type of MAPP showed significant different with MAPP 'A' gives a better performance of  $E'$  compare than MAPP 'B'.

The  $E'$  and  $E''$  increased with the addition of reactive additives compared to those without RA and the  $T_g$  reduces to low temperature as compared to the irradiated EFB/PP without RA. The  $\tan \delta$  for the irradiated EFB/PP with RAs also changed with the percentage of RA concentrations.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**KELAKUAN REOLOGI DAN SIFAT KOMPOSIT SUNTIKAN TERACU  
GENTIAN TANDAN KELAPA SAWIT (*Elaeis Guineensis*  
Jacq.)/POLIPROPILENA**

OLEH

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Kajian terhadap kebolehlaksanaan memproses komposit dari gentian tandan buah kosong kelapa sawit (EFB)/polipropilena (PP) menggunakan suntikan acuan telah dilakukan. Ciri-ciri fizikal, kimia and terma EFB turut dikaji.

Kesan saiz gentian, kandungan gentian, aras indeks aliran leburan dan kandungan kepekatan meleat-polipropilena (MAPP) terhadap sifat-sifat mekanikal, fizikal, reologi dan terma komposit EFB/PP juga telah diteliti. Kesan jenis dan kepekatan bahan tambah bertindak balas (RA) ke atas EFB/PP yang telah disinarkan juga turut dikaji terutamanya terhadap kelakuan reologi dan cirri-ciri mekanikal dinamik terma.

Komposit EFB/PP telah dihasilkan daripada gentian EFB pulpa mekanikal terma dan damar PP. Mesin pencampur dalaman digunakan untuk mencampur bahan tersebut dan mesin suntikan acuan telah digunakan untuk membentuk spesimen menurut piawai ASTM. Alur elektron digunakan

untuk menyinarakan komposit EFB/PP bagi mengkaji sifat mekanikal dinamik terma dan kelakuan reologi. Kelakuan reologi telah dikaji menggunakan meter likat *rheostress* dan keputusannya telah dibandingkan dengan indeks aliran leburan komposit.

Saiz dan kandungan gentian telah memberi kesan yang nyata sekali kepada sifat mekanikal dan fizikal komposit EFB/PP. Walau bagaimanapun jenis dan kandungan kepekatan MAPP hanya berkesan kepada sifat tegangan dan pengecutan komposit teracu.

Reologi PP telah menunjukkan kelakuan pseudoplastik dan kelikatannya adalah malar pada kadar ricih yang rendah. Perubahan pada saiz gentian telah memberi kesan yang berbeza pada keadaan kelikatan dengan gentian halus menunjukkan lengkung kelikatan berjauhan dari lengkung matriks terutamanya pada kadar ricih yang sangat rendah. Namun begitu gentian bersaiz 0.1-0.2 mm memperlihatkan arah lengkung kelikatan yang menghampiri matriks. Apabila bahan tambah MAPP dicampurkan ke dalam komposit EFB/PP lengkung kelikatan telah berubah bergantung kepada jenis dan kandungan kepekatan bahan tambah tersebut. Didapati bahawa untuk kedua-dua jenis MAPP dengan kandungan sebanyak 2%, telah meningkatkan sedikit kelikatan tetapi kepekatan 6% telah mengurangkan kelikatan dengan nyata.

Komposit EFB/PP yang telah disinarkan menampakkan pengurangan yang nyata terhadap kelikatan namun dengan rawatan dari trimetilol propana triakrilat (TMPTA) kelikatan telah menunjukkan kenaikan tetapi berkurangan jika dirawat dengan heksadiol diakrilat (HDDA).

Sifat mekanikal dinamik terma komposit EFB/PP menunjukkan bahawa modulus penyimpanan ( $E'$ ) berkurang dengan pertambahan suhu.  $E'$  juga meningkat dengan peningkatan kandungan gentian di dalam komposit. Namun saiz gentian tidak memberi kesan kepada  $E'$ . Komposit EFB/PP telah menunjukkan suhu peralihan kaca ( $T_g$ ) teranjak ke suhu yang lebih rendah berbanding  $T_g$  untuk PP yang asli.

Rawatan MAPP telah meningkatkan  $E'$  dan modulus pelepasan ( $E''$ ). Namun begitu ( $\tan \delta$ ) kurang berkesan dengan penambahan MAPP. Jenis MAPP menunjukkan perbezaan yang merata kepada  $E'$ , dengan MAPP 'A' memberikan kesan yang lebih baik berbanding MAPP 'B'.

$E'$  dan  $E''$  telah meningkat dengan mencampurkan bahan tambah reaktif berbanding tanpa RA dan nilai  $T_g$  juga telah berkurang ke suhu rendah berbanding komposit EFB/PP yang telah disinar tanpa RA.  $\tan \delta$  untuk EFB/PP yang telah disinar dengan RA juga telah berubah dengan perbezaan peratusan kepekatan RA.



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I certify that an Examination Committee met on 13<sup>th</sup> July 2005 to conduct the final examination of Khalina Abdan on her Doctor of Philosophy thesis entitled "Rheological Behaviour and Properties of Injection Moulded Oil Palm (*Elaeis guineensis* Jacq.) Empty Fruit Bunch Fibres/Polypropylene Composites" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

  
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